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EFFECT OF BARK GROWTH IN MEASUREMENT OF PERIODIC GROWTH OF INDIVIDUAL TREES

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In estimating the periodic growth of individual forest trees, some allowance should be made for the growth in bark thickness during the period involved in the estimate. It might seem that this is an unimportant factor in growth calculations. Actually a small error results if no allowance is made for change in bark thickness.

Tables giving the volume of wood in a tree are usually related to diameter measurements made outside the bark (d.o.b.). However, the present outside-bark diameter cannot be converted accurately to outside-bark diameter a number of years ago merely by subtracting the diameter growth of the solid wood, since the thickness of the bark may have changed in the intervening period. Underestimates of growth, when increase in bark thickness is not considered, range from 0 to 6 percent. The error is greatest for fast growing trees, and least for slow growing ones.

The following example illustrates the effect of bark growth on estimates of volume growth. A ponderosa pine tree 16.0 inches outside bark at breast height which added 6 inches of solid wood to its diameter in the past 30 years would have had a diameter of 9.5 inches at the beginning of the 30-year period, because the bark grew 0.25 inch (or 0.5 inch double bark thickness) at the same time. If bark growth is not considered, the diameter at the beginning of the 30-year period would be calculated as 10.0 inches. The effect on volume is shown as follows:

	No allowance for bark growth	With allowance for bark growth
	-- Cubic feet - inside bark --	
Volume at present	26.0	26.0
Volume 30 years ago	9.5	8.6
Increase in volume	16.5	17.4
Underestimate of growth	5%	--

The periodic change in bark thickness differs greatly between species. Data for 646 trees of 12 species in the Northern Rocky Mountain region were analyzed for the purpose of determining average factors for converting present diameter, outside bark, to past diameter, outside bark. These factors presented in the following tabulation are believed to be applicable throughout the region, and to be satisfactorily accurate for trees 4 inches and larger:

Species	Formulae for d.b.h.(o.b.) n years ago	Basis Number of trees
Douglas-fir	a = A - 2.309g	156
Western white pine	a = A - 2.075g	126
Western larch	a = A - 2.350g	71
Lodgepole pine	a = A - 2.064g	63
Ponderosa pine	a = A - 2.178g	43
Engelmann spruce	a = A - 2.028g	40
Western redcedar	a = A - 2.105g	26
Western hemlock	a = A - 2.141g	25
Grand fir	a = A - 2.186g	24
Alpine fir	a = A - 2.062g	8
Black cottonwood	a = A - 2.267g	44
Aspen	a = A - 2.193g	20

when - a = d.b.h.(o.b.) n years ago
A = current d.b.h.(o.b.)
g = n years radial growth, not including bark

Method of Deriving Factors

The factors in the above tabulation were developed in two steps as follows:

Step 1 - A regression equation of d.b.h.(i.b.) on d.b.h.(o.b.) was determined for each species. 1/

1/ Bruce and Schumacher, 1935, Forest Mensuration, page 183, McGraw Hill Book Company, New York. These authorities conclude from long experience that a straight line relation of d.b.h.(o.b.) and bark thickness is suitable for practical usage. Substitution of d.b.h.(i.b.) for bark thickness is a restatement of the same relation. This straight line was fitted by the method of least squares.

Step 2 - Then using the formula $x = X - 2g$ when

x = d.b.h.(i.b.) n years ago
X = current d.b.h.(i.b.)
g = n years radial growth of wood

Equality values of x and X from the regression equations were substituted in this formula, and the resulting equations simplified to that given for each species in the tabulation on page 2.

The development of the ponderosa pine equation is given below to illustrate the method. The regression equation for ponderosa pine was determined to be: d.b.h.(i.b.) = .918 d.b.h.(o.b.) - 392; then

I $\quad x = X - 2g$

II $\quad x = .918a - .392$

III $\quad 0 = X - 2g - .918a + .392$ simultaneous solution of equations I and II.

or

$.918a = X - 2g + .392$

Substituting $.918A - .392$ for X, equation III becomes:

IV $\quad .918a = .918A - .392 - 2g + .392$

or

$$a = A - \frac{2g}{.918}$$

V $\quad a = A - 2.178g$

An example illustrates how the formula may be applied to find d.b.h. (o.b.) 10 years ago for a ponderosa pine tree. If the current d.b.h. (o.b.) is 22.4 inches and 10 years radial growth (not including bark) is 0.7 inches, then

d.b.h. 10 years ago = 22.4" - 2.178 x 0.7" or 20.9"

In the 10-year period double bark thickness increased 0.1 inch and the solid wood increased 1.4 inches in diameter.

The procedure described herein is being used in the Forest Survey for growth calculations in the Northern Rocky Mountain region.